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METEOROLOGICAL OFFICE

CLIMATOLOGICAL MEMORANDUM NO. 37

Estimation of FREQUENCY DISTRIBUTIONS OF HOURLY TEMPERATURES ABOVE OR BELOW ANY DESIRED BASE TEMPERATURE for places in Northern Ireland using long-period averages of daily maximum and minimum temperatures

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This memorandum describes in detail the application of the relationship given by Shellard and Sarson (1) to places in Northern Ireland. The graphs attached to this memorandum show, as the main pecked line, the smooth curve through the Shellard-Sarson points calculated for Aldergrove, Co. Antrim. Their nine-station mean curves are shown as faint dotted lines only where there is more than 0.05 displacement from the Aldergrove curve for values of $(t - \overline{T})/(T_x - T_n)$. The graphs are grouped seasonally.

It is recommended that for inland places in Northern Ireland, the Aldergrove curves should be used, whereas the Shellard-Sarson nine-station mean curves probably apply better to places on or near the coast.

METHOD

1. Basic data required: Monthly averages of daily maximum temperature and of daily minimum temperature based on observations over a period of at least 10 years (e.g. the Meteorological Office standard period of 30 years (2)) or, if these are not available, similar averages based on whatever records are available, weighted by reference to the nearest suitable long-period station. If actual data are not available, and maps of average daily maximum and of daily minimum temperature are, then these may be used to estimate the monthly averages. However, such maps are usually drawn as at mean sea level, and it will, therefore, be necessary to apply the standard height correction to values (i.e. -1.0°C. per 500 feet altitude above sea level).

   Monthly averages of temperature for stations in Northern Ireland for the current standard period, 1931-1960, are available (3).

2. Stage 1: Calculate from the monthly averages, noting the sign, positive or negative values of

$$\frac{(t - \overline{T})}{(T_x - T_n)}$$

   where t = the selected base temperature,
   $\overline{T}$ = the daily mean temperature, which, if not published, may be obtained from $\frac{1}{2}(T_x + T_n)$,
   T_x = the monthly mean daily maximum temperature,
   and T_n = the monthly mean daily minimum temperature.

   $(T_x - T_n)$ is, therefore, the mean daily range of temperature for the month.

3. Stage 2: Using each of the monthly graphs, find the appropriate month's percentage (P_a) for the values calculated at Stage 1. Note that the graphs are drawn on arithmetic probability paper, and that, whilst the scale of the abscissae $(t - \overline{T})/T_x - T_n)$ is linear, the ordinate (percentage frequency, P_a) is not linear

   The values thus obtained from the twelve graphs represent the percentage amount of time (hours) that the temperature is above the selected base temperature, or average, in each of the twelve months.

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If the average duration (in hours) is required, rather than the percentage, then this can be calculated from:-

$$h_a = \frac{P_a \cdot h_m}{100}$$

where h_m = the number of hours in a month (i.e. 744 for a month with 31 days, 720 for a month with 30 days, and 672 for February, the Leap Year anomaly being ignored).

4. Stage 3: If the percentage time, on average, that the temperature is below the selected base temperature is required then

$$P_b = 100.0 - P_a$$

P_a having been obtained at Stage 2. Similarly, if the duration, rather than the percentage, is required then

$$h_b = h_m - h_a$$

where h_a was found in the latter part of Stage 2.

5. Stage 4: If the percentage amount of time over the average year as a whole is required, this can be determined as follows:

METHOD 1.

$$P_a \text{ (year)} = \frac{100 \text{ x the sum of twelve months values of } h_a}{\text{the sum of the hours in a year (= 8760)}}$$

$$P_b \text{ (year)} = \frac{100 \text{ x the sum of twelve months values of } h_b}{\text{the sum of the hours in a year (= 8760)}}$$

If, however, it has not been necessary to calculate either values of h_a or h_b, the work being restricted to percentage time, then a close approximation to the percentage time over the year as a whole can be obtained from

METHOD 2.

$$P_a \text{ (year)} = \frac{\text{the sum of the twelve monthly values of } P_a}{12}$$

$$P_b \text{ (year)} = \frac{\text{the sum of the twelve monthly values of } P_b}{12}$$

If the average duration, rather than the percentage, over the year is required, then this can be obtained simply by adding the twelve monthly values of h_a or h_b, as appropriate.

6. Example: An example is appended to show the percentage time, on average, (monthly and annually), that the temperature at Aldergrove is above 10.0°C. (50°F.), and below that temperature, and also to show the average duration (in hours), both monthly and annually. This example gives an indication of the closeness of the annual results using Method 1 and Method 2.

REFERENCES

(1) Shellard, H.C. and Sarson, P.B., "Estimation of frequency distributions of hourly temperatures at United Kingdom stations from monthly averages of daily maxima and minima", Met.Mag. Vol.91, January, 1962, pp.19-26. (H.M.S.O., 2s. 6d.)

(2) Averages of temperature for Great Britain and Northern Ireland, 1921-1950, (Code M.O.571), H.M.S.O., price 3s. 0d.

(3) The Northern Ireland temperatures included in Reference (2) are amplified in roneoed papers available from the Meteorological Office, Belfast. They are, however, now superseded by averages in respect of the later standard period, 1931-1960.

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Meteorological Office

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C o r r i g e n d u m

Distribution: As for CM.37

GRAPH: Autumn Season: OCTOBER

Please note that the values of $\frac{t - \bar{T}}{T_x - T_n}$ marked along the top of the graph are misplaced by 1.0: the top markings should be amended to agree with those shown at the bottom of this graph, which are correct.

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EXAMPLE To determine the monthly and annual percentage of time the temperature is above and below the base temperature of 10.0°C. (50°F.) at Aldergrove; and the average number of hours above and below the base temperature. Let P_a = percentage above base temperature, P_b = percentage below base temperature, h_a = number of hours above base temperature, and h_b the number of hours below base temperature. h_m = the number of hours in the month.

Aldergrove		Jan	Feb	Mar	Apr	May	Jun	Jly	Aug	Sep	Oct	Nov	Dec	Year
Mean daily max.	T_x =	6.0	6.8	9.2	11.8	14.9	17.5	18.4	18.3	16.1	12.6	9.1	6.9	
Mean daily min.	T_n =	1.5	1.5	2.7	3.9	6.1	9.2	11.0	10.7	9.2	6.8	4.1	2.9	
Mean temperature	$\bar{T}$ =	3.7	4.2	5.9	7.9	10.5	13.3	14.7	14.5	12.7	9.7	6.6	4.9	
$t = 10.0$	$t - \bar{T}$ =	+6.3	+5.8	+4.1	+2.1	-0.5	-3.3	-4.7	-4.5	-2.7	+0.3	+3.4	+5.1	
	$T_x - T_n$ =	4.5	5.3	6.5	7.9	8.8	8.3	7.4	7.6	6.9	5.8	5.0	4.0	
	$\frac{(t - \bar{T})}{(T_x - T_n)}$ =	+1.40	+1.09	+0.63	+0.27	-0.06	-0.40	-0.63	-0.59	-0.39	+0.05	+0.68	+1.27	
From graphs	P_a =	3.5	10.0	10.5	23	52	80	92	92.5	76	45	15.5	5.5	Cross-total = 505.5
$\frac{P_a \cdot h_m}{100}$ =	h_a =	26	69	78	166	387	576	685	688	547	335	112	41	Cross-total = 3710 hours
$(100.0 - P_a)$ =	P_b =	96.5	90.0	89.5	77	48	20	8	7.5	24	55	84.5	94.5	Cross-total = 694.5
$(h_m - h_a)$ =	h_b =	718	603	666	554	357	144	59	56	173	409	608	703	Cross-total = 5050 hours

To obtain P_a for the year as a whole: Method 1. $\frac{100 \sum h_a}{\sum h_m} = \frac{100 \times 3710}{8760} =$ 42.3 per cent

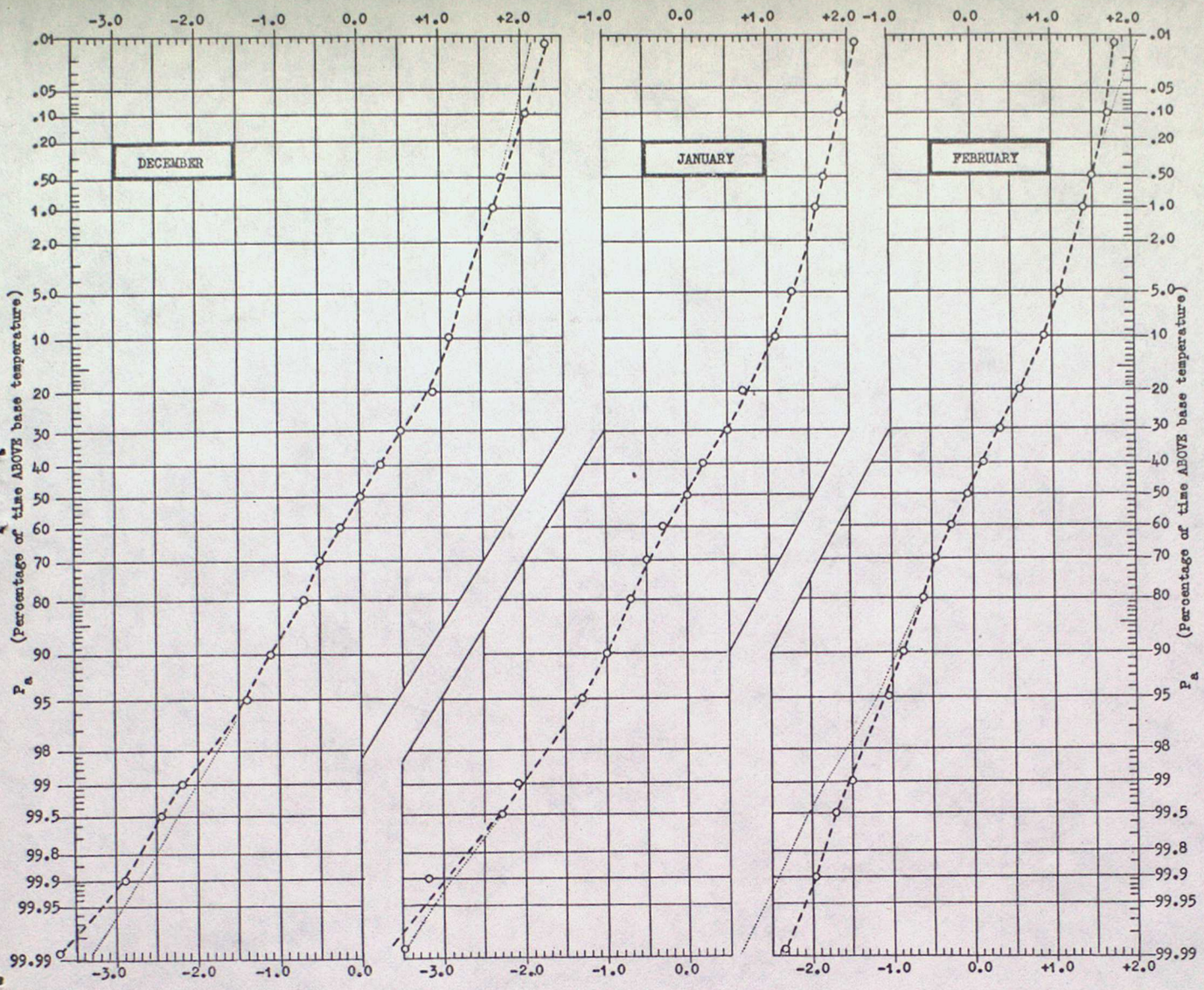
Method 2 $\frac{\sum P_a}{12} = \frac{505.5}{12} =$ 42.1 per cent

Similarly P_b for the year as a whole: Method 1. $\frac{100 \sum h_b}{\sum h_m} = \frac{100 \times 5050}{8760} =$ 57.7 per cent

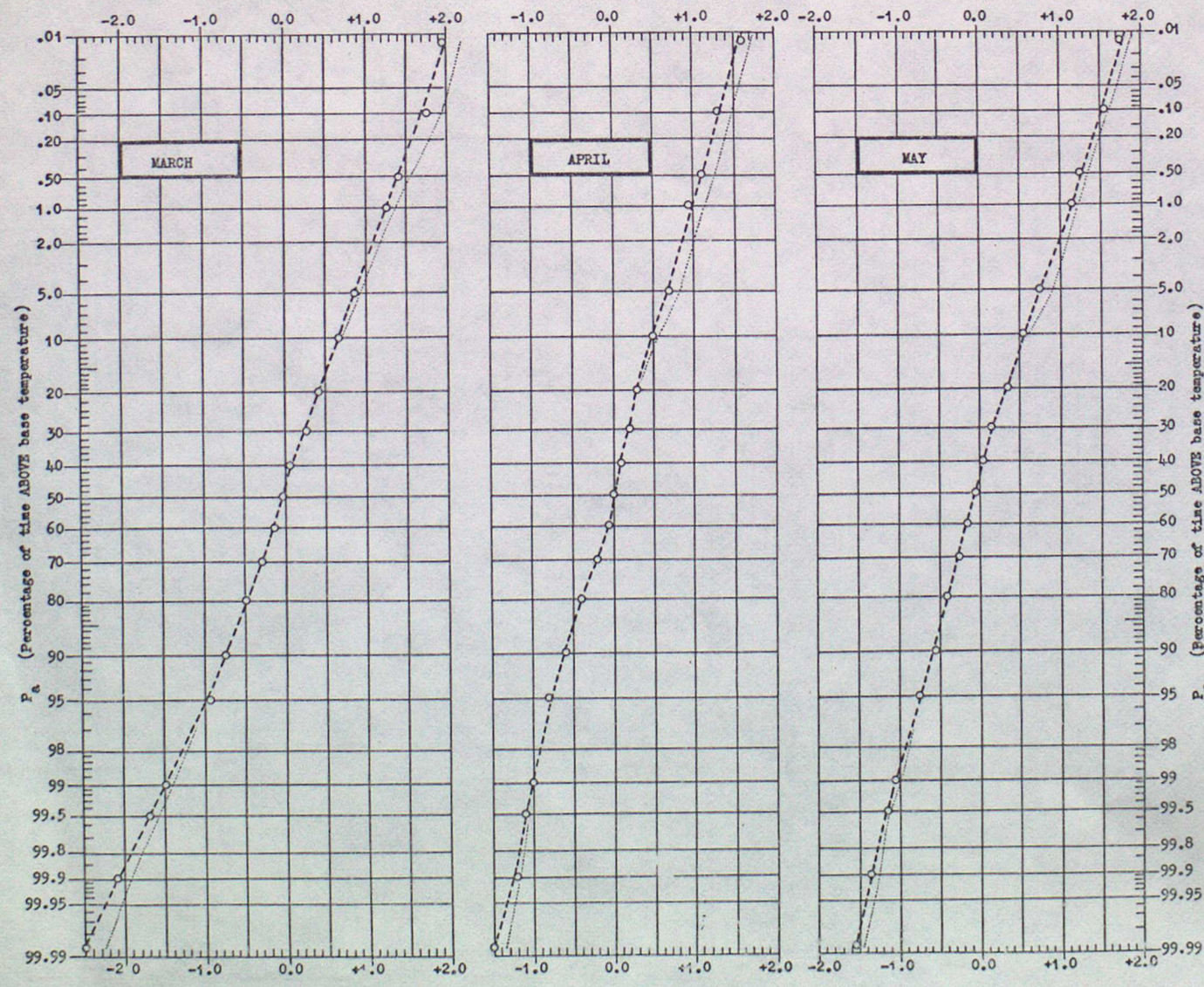
Method 2 $\frac{\sum P_b}{12} = \frac{694.5}{12} =$ 57.9 per cent

NOTE: If interest is primarily in the percentage time above or below the base temperature, it may be more convenient to use Method 2 to obtain the annual values of P_a or P_b as this does not involve calculation of the monthly values of h_a or h_b. The answer obtained by Method 2 will probably be sufficiently accurate for most purposes

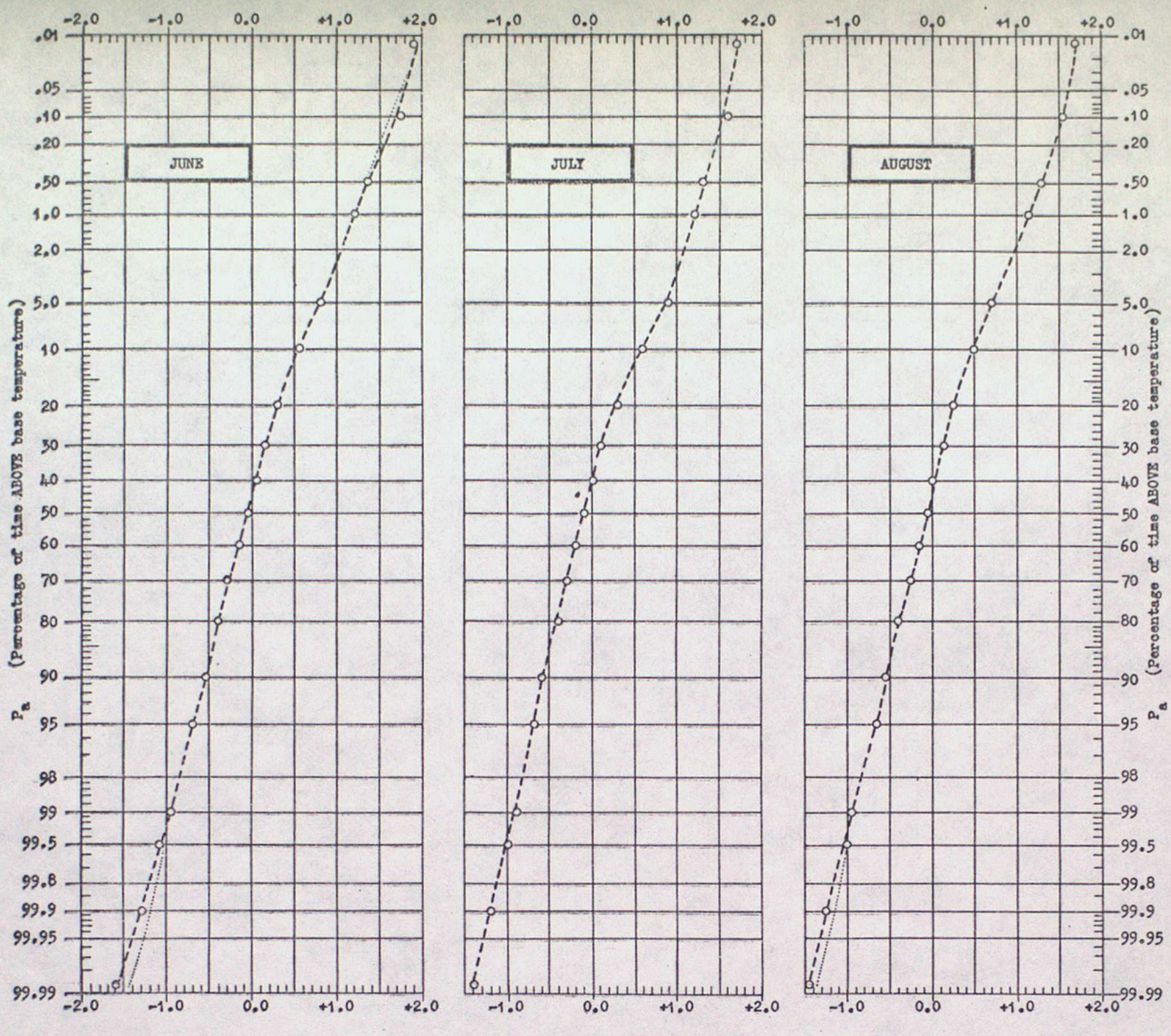
WINTER SEASON



SPRING SEASON



SUMMER SEASON



AUTUMN SEASON